# Forbes Lake Water Quality

*A Report on Water Quality Monitoring Results*
*for Water Year 2011*

Prepared for the City of Kirkland
*by the King County Lake Stewardship Program*

February 10, 2012

King County

## Overview

In May 2006, residents at Forbes Lake began monitoring water quality through participation in the King County Lake Stewardship Program (KCLSP), and efforts have continued through 2011. Physical and chemical data collected through five years of monitoring suggest that this small lake in the city of Kirkland is moderate to high in primary productivity (mesotrophic-eutrophic), with fair water quality. Primary productivity refers the rate at which algae in the lake grow and reproduce. (The terms oligotrophic, mesotrophic, and eutrophic refer respectively to low, medium, and high productivity of algae in a lake. See the section on trophic state indicators for a discussion of these terms.)

Although there is no public access boat ramp, there are several public parcels adjacent to the lake, and opportunities exist for members of the public to access the lake at several points, as well as to launch small car-top boats. This presents a potential vector for the introduction of noxious weeds to the lake. Residents should keep a watch on aquatic plants growing near shore to catch early infestations of Eurasian milfoil, Brazilian elodea, or other noxious weeds.

Later in this report references will be made to two common measures used to predict water quality in lakes: the Trophic State Index or TSI (Carlson 1977), and the ratio of nitrogen to phosphorus (N:P). The TSI values and N:P ratios were calculated from the data collected through the volunteer monitoring program. TSI values are derived from a regression that relates values of a parameter such as total phosphorus, chlorophyll *a* or Secchi transparency to algal bio-volume present, assigning a number on a scale of 0 to 100. This scale can be used to compare water quality over time and between lakes.

Further introduction and a discussion of the philosophy of the volunteer lake monitoring program and the parameters measured can be found on-line at:

http://your.kingcounty.gov/dnrp/library/archive-documents/wlr/waterres/smlakes/2006_Intro.pdf

The discussion in this report focuses on the 2011 water year. Specific data used to generate the charts in this report can be downloaded from the King County Lake Stewardship data website at:

http://your.kingcounty.gov/dnrp/wlr/water-resources/small-lakes/data/default.aspx

Or can be provided in the form of excel files upon request.

## Physical Parameters

Excellent **precipitation** and **water level** records were compiled for the 2011 water year (Figure 1). Water levels rose quickly in response to heavy or prolonged rain events during the period, which suggests that precipitation in the drainage basin has limited infiltration into soils and flows quickly as surface water into the lake. Because the area of the watershed is large relative to the size of the lake, surface water flow from the watershed is likely to affect lake levels more than direct precipitation on the surface of the lake. Data collected since May 2006 suggest the lake does not vary a great deal through the year in response to seasonal climatic changes, although it will drop slowly during dry periods (see July through September on Figure 1). Throughout 2011 the lake level varied around a relatively constant base level that may relate to groundwater levels, with short-lived increases that mostly can be related to rainfall events. The highest lake levels do not appear to persist longer than a week.

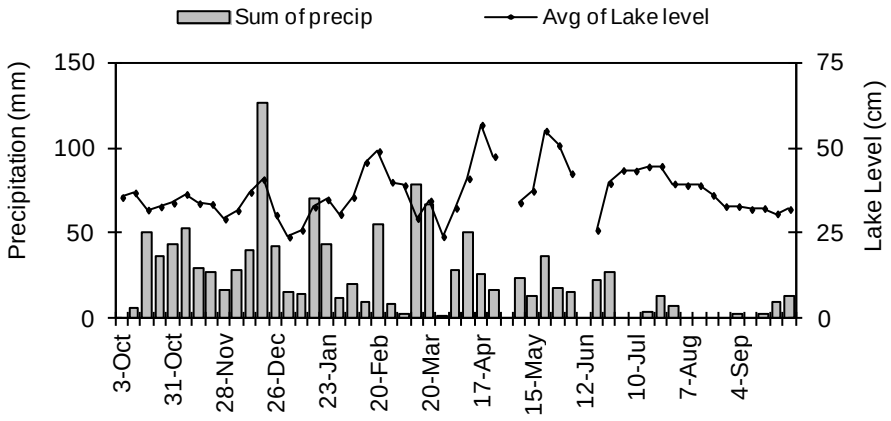


**Figure 1. WY 2011Forbes weekly Lake Level and Precipitation**

**Secchi transparency** is a common method used to assess and compare water clarity. It is a measure of the water depth at which a black and white disk disappears from view when lowered into the water from the surface.

Volunteers collected Secchi transparency and temperature data from early May through late October during the "Level 2" monitoring season when volunteers collect water samples for laboratory analyses. Secchi transparency from May through October ranged between 1.8 and 3.0 meters (Figure 2). The summer average transparency was 2.5 m, which placed it in the lower range of water clarity for monitored small lakes in 2011. Throughout the sampling season the Secchi clarity remained fairly consistent, suggesting that no algae blooms impacted transparency significantly at any time during the monitoring season.

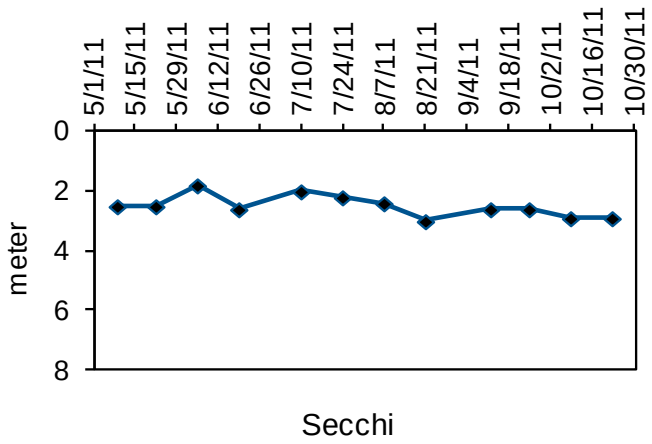


**Figure 2. WY 2011 Forbes Secchi Levels**

**Shallow water temperatures** at 1 m ranged between 13.5 to 23.5 degrees Celsius, with an average of 19.0 degrees Celsius (Figure 3). The maximum temperature in late August coincided with the maxima at other lakes in the Puget Sound lowlands. Due to the wetter and cooler spring and early summer conditions in 2011, area lakes were slower to warm up and did not have the same maximum temperatures that have been observed in years past.

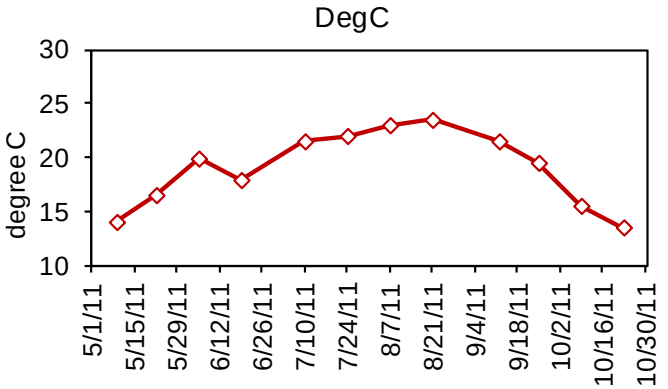


**Figure 3. WY 2011 Forbes Temperature**

## Nutrient and Chlorophyll Analysis

**Phosphorus** and **nitrogen** are naturally occurring elements necessary in small amounts for both plants and animals. However, many actions associated with residential development can increase concentrations of these nutrients beyond natural levels. In lakes of the Puget Sound lowlands, phosphorus is often the nutrient in least supply, meaning that biological primary productivity (from algae) is often limited by the amount of available phosphorus. Increases in phosphorus concentrations can lead to more frequent and dense algae blooms – a nuisance to residents and lake users, and a potential health and safety threat if blooms become dominated by species that can produce toxins.

Samples collected by volunteers are analyzed for total phosphorus (TP) and total nitrogen (TN) concentrations at one meter depth between May and October. During the monitoring period, the highest TN values were found in the second sample of the season, with a slight decrease through the first part of the sample season, but then remained stable through September and October (Figure 4). TP followed a similar pattern.

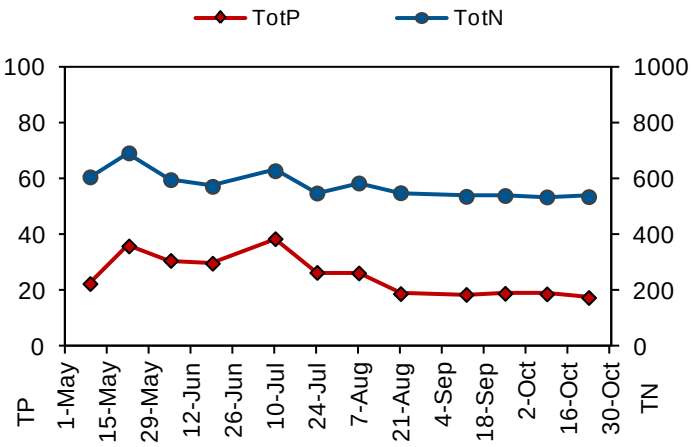


**Figure 4. 2011 Forbes Lake Total Phosphorus and Total Nitrogen Concentrations**

The ratio of nitrogen to phosphorus (N:P) can be used to determine if conditions are favorable for the growth of cyanobacteria (bluegreen algae), whose presence can negatively impact beneficial uses of the lake. When N:P ratios are near or below 20, cyanobacteria can dominate the algal community due to their ability to take nitrogen from the air. Total phosphorus and total nitrogen remained in relatively constant proportion to each other through the sampling period, with the ratio of nitrogen to phosphorus (N:P) ranging from 16.3 to 30.8 with an average of 24.2. While nutrient conditions were good for bluegreens during the first half of the season, during the second half they were not as favorable for nuisance bluegreen growth.

**Chlorophyll *a*** concentrations reached a maximum in mid June (Figure 5, followed by a decrease and then a slow climb again from September to the end of the monitoring season Pheophytin, which is a degradation product of chlorophyll, was generally at low detection levels throughout the period.

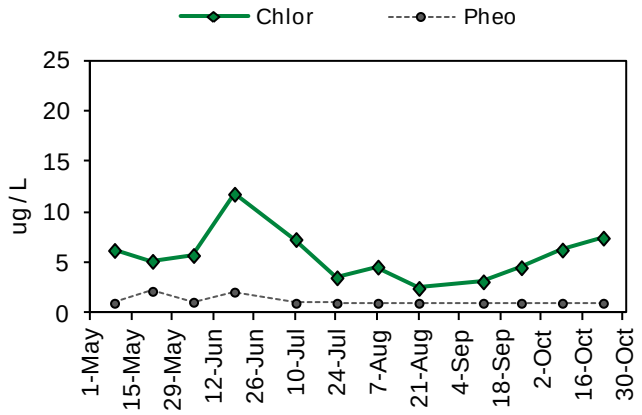


**Figure 5. WY 2011 Forbes Chlorophyll *a* and Pheophytin concentrations**

Profile data indicate that thermal stratification (temperature layering) was present in early summer and persisted through the second profile event in late August (Table 1). Cool temperatures in the deep water may indicate some influence of ground water inflows. Higher concentrations of both total and dissolved phosphorus were found in the deep water in May and especially in August, suggesting that anoxia (lack of oxygen) could have triggered a release of phosphorus from the sediments. High ammonia (NH3) concentrations in the deep water also indicate deep water anoxia.

Chlorophyll *a* profile data indicate that algae are present throughout the water column, but were distributed unevenly in August, with higher concentrations developing throughout the water column. The highest concentration of algae occurred in the seven meter sample in the August profile, which suggests that at that time there was a reservoir of algae in the deep water, where nutrients were plentiful.

**Table 1. Forbes Lake Profile Sample Analysis Results. Secchi and Depth in meters. Temperature in degrees Celsius. Chlorophyll and Pheophytin in ug/L. Nitrogen, phosphorus, and alkalinity in mg /L. UV254 is in absorption units. Sample values below minimum detection level are marked <MDL.**

| Lake name | Date | Secchi | Depth | DegC | Chlor-a | Pheo | Total N | NH3 | Total P | OPO4 | UV254 | Total Alk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Forbes | 5/22/11 | 2.5 | 1 | 16.5 | 5.2 | 2.2 | 0.693 | 0.054 | 0.0359 | 0.0055 | 0.335 | 54.5 |
| Forbes | 5/22/11 | | 4 | 9.5 | 1.3 | 1.8 | 0.609 | | 0.0265 | | | |
| Forbes | 5/22/11 | | 7 | 6.5 | 0.8 | 1.2 | 0.905 | 0.281 | 0.0492 | 0.0160 | | |
| Forbes | 8/21/11 | 3.0 | 1 | 23.5 | 2.5 | <MDL | 0.550 | <MDL | 0.0188 | 0.0024 | 0.352 | 71.1 |
| Forbes | 8/21/11 | | 4 | 12.0 | 6.3 | 3.7 | 0.373 | | 0.0165 | | | |
| Forbes | 8/21/11 | | 7 | 6.5 | 20.4 | | 1.800 | 1.590 | 0.5650 | 0.0961 | | |

NOTE: In Table 1, <MDL stands for "below minimum detection level" of the analytical method.

The moderate values for UV254 indicate that the water of the lake is colored from organic substances, which probably is affecting the Secchi transparency values. The total alkalinity values show that the water in the lake is less soft than regional lakes in undeveloped watersheds and thus has more buffering against pH change.

## Trophic State Index Ratings

A common method of tracking water quality trends in lakes is by calculating values for the "trophic state index" (TSI), developed by Robert Carlson in 1977. TSI values predict the biological productivity of the lake. The TSI is based on water clarity (Secchi), concentrations of total phosphorus (TP), and chlorophyll *a*. The Index relates to 3 categories of productivity:

- *oligotrophic* (low productivity, below 40 on the TSI scale - low in nutrient concentrations, small amount of algae growth);
- *mesotrophic* (moderate productivity, between 40 and 50 on TSI scale – moderate nutrient concentrations, moderate growth of algae growth); and
- *eutrophic* (high productivity, above 50 – high nutrient concentrations, high level of algae growth).

The 2011 TSI value for TP was right on the eutrophic threshold, while the TSI value based on Secchi transparency (water clarity) and TSI indicator for Chlorophyll *a* were slightly lower, in the upper end of the mesotrophic range (Figure 6). The average of all 3 TSI indicators in 2011 put Forbes Lake into the upper mesotrophic range for the year, lower than the 2010 average. Additional years of monitoring are necessary to perform trend analysis to determine if the trophic status of Forbes Lake is relatively stable or following an upward trend in algal productivity.

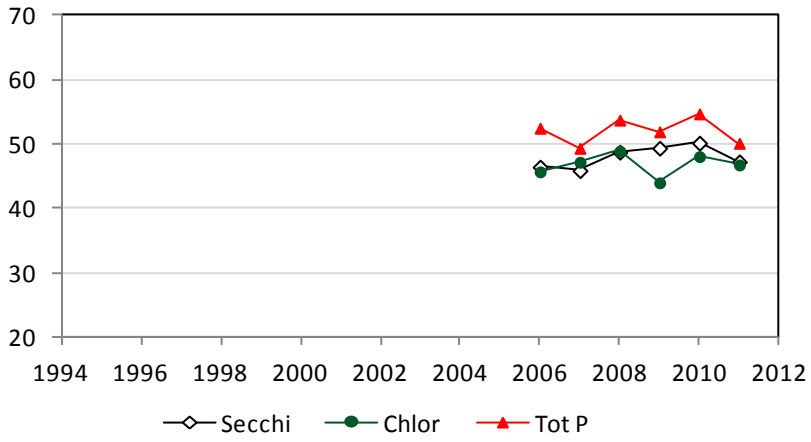


**Figure 6. 2011 Forbes Lake Trophic State Indicators**

## *Conclusions and Recommendations*

Based on monitoring data, water quality in Forbes Lake has not varied a great deal over the period measured, but may be showing signs of an increasing trend over time. However, not enough data has been collected yet to verify trends statistically. Low N:P ratios could indicate nutrient conditions are favorable for nuisance bluegreen algae blooms, particularly in the spring and summer.

Monitoring of nutrient and chlorophyll concentrations should be continued to see if an increasing trend can be verified. Close monitoring of algae blooms at the lake should also be done, including participation in the Washington State Department of Ecology's Toxic Algae Monitoring program to determine whether or not blooms found in the lake may occasionally produce toxins.